In the Specification:

On page 1, after the title insert the following:

RELATED APPLICATIONS

This is a U.S. national stage of application No. PCT/DE2003/002071, filed on June 20, 2003.

This patent application claims the priority of German patent application no. 102 34 977.0, filed July 31, 2002, the disclosure content of which is hereby incorporated by reference.

FIELD OF THE INVENTION

Page 1, amend the paragraph beginning on line 6 as follows:

The present invention relates to radiation-emitting thin-film semiconductor components based on GaN ~~according to the preamble of patent claim 1 and according to the preamble of patent claim 18~~.

Page 1, before line 11, insert the following heading:

BACKGROUND OF THE INVENTION

Page 1, amend the paragraph beginning on line 34 as follows:

Therefore, one possibility for reducing the absorption losses and thus for increasing the external efficiency is the removal of the carrier substrate ~~in conjunction with~~ <u>and to apply</u> suitable mirror layers <u>to the component</u> (thin-film concept). However, a semiconductor thin film is essentially a co-planar plate whose coupling-out efficiency is

not increased compared with a standard diode on account of the geometry. Particularly if a carrier substrate exhibiting only little absorption (for example GaN on SiC) has already been used for the semiconductor component, the increase in the external efficiency of the thin-film semiconductor component is too small to justify the increased technical effort for removing the carrier substrate.

On page 2, amend the paragraph beginning on line 38 through page 3 line 10 as follows:

Therefore, there are already various approaches for increasing the external efficiency of semiconductor components through altered geometries. Mention shall be made here, in particular, of a so-called micropatterning of the entire multilayer structure, which leads to an intensified lateral coupling out of radiation on account of the larger total area of the side areas of the multilayer structure. In addition, the side areas of the individual multilayer structures thus produced may be beveled. Examples of such semiconductor components are disclosed in DE-A-198 07 758, (corresponding to US Patent No. 6,229,160) EP-A-0 905 797 (corresponding to US Patent No. 6,111,272) or JP-A-08-288543.

Page 3, before line 36, insert the following heading:

SUMMARY OF THE INVENTION

Page 3, amend the paragraph on line 36 as follows:

~~The present invention is based on the object of providing~~ One object of the present invention is to provide a radiation-emitting thin-film semiconductor component based on GaN which has an improved external efficiency of coupling out radiation.

On page 4, delete the paragraph beginning on line 1 in its entirety.

On page 4, amend the paragraph beginning on line 9 as follows:

~~The radiation-emitting thin-film semiconductor component according to the invention has~~ This and other objects are attained in accordance with one aspect of the present invention directed to a multilayer structure based on GaN, which contains an active, radiation-generating layer and has a first main area and a second main area - remote from the first main area - for coupling out the radiation generated in the active, radiation-generating layer. Furthermore, the first main area of the multilayer structure is coupled to a reflective layer or interface, and the region of the multilayer structure that adjoins the second main area of the multilayer structure is patterned one- or two-dimensionally.

On page 4, amend the paragraph beginning on line 30 as follows:

~~Preferably, the~~ The region of the multilayer structure that adjoins the second main area of the multilayer structure ~~has~~ can have convex elevations in the form of truncated pyramids, truncated cones, cones or sphere segments (two-dimensional

patterning) or with a trapezoidal, triangular or circle segment cross-sectional form (one-dimensional patterning).

On page 4, amend the paragraph beginning on line 38 as follows:

In ~~a preferred exemplary~~ one embodiment, the aperture angle of the elevations lies between approximately 30° and approximately 70°, ~~particularly~~ and preferably between approximately 40° and approximately 50°. Moreover, the height of the elevations is at least as large, preferably approximately twice as large, as the height of a plane region of the multilayer structure between the active, radiation-generating layer and the elevations. The grid dimension of the elevations is chosen to be at most approximately five times, preferably at most approximately three times, as large as the height of the elevations.

On page 5, delete the paragraph beginning on line 33 in its entirety.

On page 6, amend the paragraph beginning on line 1, as follows:

This radiation-emitting thin-film semiconductor component according to the invention likewise has a multilayer structure based on GaN, which contains an active, radiation-generating layer and has a first main area and a second main area - remote from the first main area - for coupling out the radiation generated in the active, radiation-generating layer. The first main area of the multilayer structure is ~~once again~~ coupled to a reflective layer or interface. ~~In contrast to the semiconductor component described above, here a~~ A transparent layer is provided between the first main area of the

multilayer structure and the reflective layer or interface, said transparent layer being patterned one- or two-dimensionally.

On page 6, amend the paragraph beginning on line 33 as follows:

In ~~a preferred~~ one embodiment, said elevations have an aperture angle of between approximately 30° and approximately 70°, preferably between approximately 40° and approximately 50°. In this case, the height of the elevations is chosen to be at least as large, preferably approximately twice as large, as the height of a plane region of the multilayer structure between the active, radiation-generating layer and the elevations, and the grid dimension of the elevations is at most five times, preferably at most three times, the height of the elevations.

On page 7, delete the paragraph beginning on line 17 in its entirety.

On page 7, after line 21 insert the heading

BRIEF DESCRIPTION OF THE DRAWINGS.

On page 7, amend the paragraph beginning on line 33 as follows:

Figures 3A to ~~3E~~ 3D show results of various simulations for elucidating various optimal parameters of the elevations of the semiconductor component from Figure 1;

On page 7, insert the following paragraph after line 36:

Figure 3E shows the external coupling-out efficiency as a function of the refractive index of the antireflection layer for the embodiment of Figure 6.

On page 8, before line 22, insert the following heading:

DETAILED DESCRIPTION OF THE DRAWINGS

On page 8, amend the paragraph beginning on line 32 as follows:

The multilayer structure 12 has a first main surface area 16 and a second main surface area 18 remote from the first main area, the radiation generated in the active, radiation-generating layer 14 finally being coupled out of the semiconductor component 10 through the second main surface area 18. In the exemplary embodiment shown, the active layer 14 is positioned nearer to the first main surface area 16 than to the second main area surface 18 of the multilayer structure 12. However, the present invention is in no way restricted to this. Rather, the active layer 14 may also be formed centrally in the multilayer structure 12 or nearer to the second main surface area 18. The position chosen in figure 1 is advantageous, however, for the patterning of the multilayer structure that is in accordance with the invention and is described below, since a thicker portion of the multilayer structure 12 is available for the patterning.

On page 9, amend the paragraph beginning on line 26 as follows:

As is clearly discernable in Figure 1, the region of the multilayer structure 14 above the active layer 12 can be subdivided essentially into a plane region 20 adjoining the active layer 14 and a patterned region 22 adjoining the second main surface area 18. The multilayer structure 12 is patterned for example by means of customary lithography and/or etching methods at the epitaxially grown semiconductor layers, by means of which groovelike recesses or depressions 24 are formed, between which corresponding elevations 26 remain.

On page 9, amend the paragraph beginning on line 37 as follows:

The patterning of the multilayer structure 12 may be formed either one-dimensionally, that is to say with depressions 24 in only one coordinate direction of the plane of the second main surface area 18, or two-dimensionally, that is to say with depressions 24 in two coordinate directions - preferably running perpendicular to one another - of the plane of the second main surface area 18. The elevations 26 produced between the depressions 24 are usually shaped in convex fashion. In this case, one-dimensional patternings are formed by way of example with a trapezoidal (see figure 1), triangular, circle segment or hemispherical cross-sectional form and two-dimensional patternings are correspondingly formed in the form of truncated pyramids, truncated cones, cones, sphere segments or hemispheres.

On page 10, amend the paragraph beginning on line 27 as follows:

As illustrated in Figures 2A to 2C, the efficiency of coupling out radiation depends on the aperture angle α of the elevations 26. Very steep sidewalls, as in Figure 2A, increase the surface area of the device and are thus expedient for coupling out radiation, but ~~a reduction of~~ the number of optical modes that ~~cannot be~~ are not coupled out ~~on account of~~ due to total reflection is not ~~obtained in this case~~ reduced in the case of very steep sidewalls. Likewise, the sidewalls of the elevations 26 should not be chosen to be too shallow, as illustrated in Figure 2C, since in this case the deviation from the plane-parallel plate is only small and a large number of multiple reflections

~~have to be effected~~ occur before coupling out of the radiation. These multiple reflections affect the efficiency of the device in a negative way due to absorption of the radiation within the component. ~~, which is negative on account of the unavoidable attenuation in this case~~.

On page 11, amend the paragraph beginning on line 14 as follows:

This estimation is also confirmed by a simulation, the result of which is shown in Figure 3A. In this case, the pyramid angle $\alpha/2$ (where α is an aperture angle) ~~aperture angle α~~ of the elevations 26 in truncated pyramid form is plotted on the abscissa, and the external efficiency of coupling out radiation is plotted on the ordinate. It is clearly evident that the best efficiency is achieved in a range of the ~~aperture angle α~~ pyramid angle between approximately 30° and approximately 70°, more precisely between approximately 40° and approximately 50°. The efficiency of coupling out radiation falls significantly for values of the ~~aperture angle α~~ pyramid angle above 70° and below 30°. ~~An aperture angle α~~ A pyramid angle in the range around approximately 45° is thus preferable.

On page 12, amend the paragraph beginning on line 38 as follows:

Figure 4 illustrates a modification of the semiconductor component from Figure 1. The difference between the two embodiments is that a protective or antireflection layer 32 is provided on the patterned second main surface area 18 of the multilayer structure 12. Said protective layer 32 is intended to protect the semiconductor from external

influences, on the one hand, and the protective layer 32 may, on the other hand, act as an antireflective coating given a suitable choice of refractive index and thickness.

On page 13, amend the paragraph beginning on line 10 as follows:

As a further variant of the first exemplary embodiment of the semiconductor component, a transparent, conductive layer (such as layer 32 shown in Fig. 4) with the lowest possible contact resistance with respect to the semiconductor may be provided on the patterned second main surface area 18 of the multilayer structure 12. Such a transparent, conductive layer makes it possible to compensate for the disadvantage that the patterning of the multilayer structure for increasing the efficiency of coupling out radiation at the same time reduces its transverse conductivity. An optimum current supply to all regions of the semiconductor component is obtained without impairing the coupling-out of radiation from the multilayer structure by metal contacts on the latter.

On page 13, amend the paragraph beginning on line 35 through page 14 line 13 as follows:

The thin-film semiconductor component 10 has a multilayer structure 12 based on GaN with an active, radiation-generating layer 14. In contrast to the first exemplary embodiment described above, however, the second main area 18 of the multilayer structure 12, through which the radiation generated in the active layer 14 is finally coupled out, is not patterned here. Rather a transparent layer 34 is provided between the first main area 16 and the reflective layer or interface on the carrier substrate 30, said transparent layer being patterned in order to increase the coupling out of radiation.

If metals which make a good electrical contact to the multiplayer structure 12 are not particularly highly reflective (e.g., platinum on p-doped GaN) transparent layer 34 is advantageous since a metal which would not make such good contact with the material of multiplayer structure 12 and which is highly reflective can be used. For example, silver can be used as a reflective layer which would otherwise, if applied directly on multilayer structure 12, yield a contamination of the semiconductor due to migration, e.g., of silver ions into the semiconductor material. ~~This construction is preferable particularly when the metals that make good contact with the semiconductor 12 are not particularly highly reflective and, therefore, metals that reflect better, such as Ag, are intended to be used, which may contaminate the semiconductor on account of high migration~~.

On page 14, amend the paragraph beginning on line 20 as follows:

The patterning essentially corresponds to that described above on the basis of the first exemplary embodiment. However, the convex elevations 26' that are appropriate here are primarily those in the form of truncated pyramids or truncated cones or those with a trapezoidal cross-sectional form. The patterning parameters explained above with reference to figure 3 can be applied to the elevations 26' of this second exemplary embodiment. In this case, the plane layer 35 between the active layer 14 of the multilayer structure 12 and the transparent layer 34 is to be used as reference variable for choosing the height of elevations 26', preferably to be twice as high as plane layer 35.

On page 15, amend the paragraph beginning on line 1 as follows:

Typical antireflection layers 32, for example made of SiO_2 or SiN_x, have a refractive index of less than 2, with the result that the radiation partly undergoes total reflection at the interface between semiconductor 12 and antireflection layer 32. As shown in the diagram of Figure 3E, the effectiveness of the patterned antireflection layer 32 decreases significantly as the refractive index deviates increasingly from that of the semiconductor with 2.5. A patterned antireflection layer having a low refractive index may nevertheless be advantageous, however, since even a wave subjected to total reflection penetrates the material having a lower refractive index approximately to a depth of half the wavelength, although it decays exponentially in this case. The height of the patterned antireflection layer should therefore be no more than a few 100 nm and the lateral dimensions are in the micrometers range. Thus, for a height of the patterned anti-reflection layer no more than a few hundred nanometers (lower than half of the wavelengths), even waves subjected to total reflection can be coupled-out since those waves penetrate the anti-reflection layer approximately to a depth of half the wavelength.

On page 16, insert the following as the last paragraph:

The scope of protection of the invention is not limited to the examples given hereinabove. The invention is embodied in each novel characteristic and each combination of characteristics, which includes every combination of any features which are stated in the claims, even if this combination of features is not explicitly stated in the claims.